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Research on Computer Software Engineering based on Scientific Workflow

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Abstract. Co-simulation technology plays a vital role in computer software engineering design and development. How to improve resource allocation and workflow coupling computational efficiency in complex simulation is a key point in software engineering management. Scientific workflow technology is the means of support to solve the above problems. This method can simplify the complicated operation process of software product developers' collection, calculation and analysis of large-scale scientific data, realize product process customization, deployment and execution, and effectively improve the problem-solving efficiency. Based on this, the thesis uses the scientific workflow concept to implement collaborative simulation calculation in computer software engineering to improve software design efficiency.

Keywords: Scientific workflow; Computer software engineering design; Simulation.

1. Introduction

Scientific workflow is an important support method to solve the problem of resource coupling calculation in product co-simulation process. It combines workflow tasks through the relationship between logical relationships between task processes and scientific research data. Completing data processing and analysis together can effectively simplify the complex operation processes such as acquisition, processing, calculation, analysis, etc. required by product developers in the process of collaborative simulation to realize the customization, deployment and execution of product design processes. And effectively improve the efficiency of solving scientific computing problems.

At present, research on co-simulation coupling calculation based on scientific workflow management platform mainly focuses on modeling and optimization of product design process, integration and management of simulation resources, collaborative design integration technology and supporting environment. Research on product co-simulation modeling technology and resource management integration technology, realize the rational use of scientific workflow management platform for interdisciplinary and cross-regional design resources, rationally layout product structure and design process from the whole, and enhance functional modules and The independence between design processes, shorten the product design cycle, improve the comprehensive performance of products, greatly promote the development of collaborative simulation technology, and improve China's independent innovation capability and intelligent manufacturing technology. Based on this, a workflow model establishment method based on Petri net's product collaborative simulation coupling calculation process is proposed. This method utilizes the process model analysis and graphical representation ability of Petri net modeling technology, and uses Petri net as an effective tool for product co-simulation coupled computing process modeling, which can effectively establish a workflow model for collaborative simulation coupling calculation process. Secondly, the integration and configuration method of computing resources in the workflow model is proposed. The method is based on the open source scientific workflow management platform Vis Trails, which provides effective support for the implementation, operation and management of the co-simulation coupled computing process on the Vis Trails platform [1-2]. At the same time, in order to enhance the flexibility of the scientific workflow management platform for design resource integration, a method of integrating SOA (Service-Oriented Architecture) with the VisTmils platform is proposed to integrate the loose coupling characteristics of SOA into the workflow management platform. In the middle, the scientific workflow management platform flexibly manages and configures the design resources in a distributed environment, which greatly accelerates the simulation coupling calculation process in the product design process [1].

2. Process Modeling Technology based on Petri Net

2.1 Process Modeling Method Selection

There are many methods for co-simulation coupled computational process modeling, such as modeling methods based on IDEF series, UML modeling methods based on directed graphs, critical path method, design structure matrix method, and Petri net-based modeling methods [2- 3] etc. In order to facilitate computer execution and to be accepted by users, the selected modeling method is best able to formally describe the system using graphical mathematical tools, verify the correctness of the system, and evaluate the performance of the system. This paper comprehensively compares these several modeling methods. The comparison results are shown in Table 1.

Tab.1 Comparison of various modeling methods

Modeling type	Comprehension	Skills of analyze	Description ability	Formalization	Normative
Critical path method	Easy to understand	general	More accurate	general	weak
Design structure matrix method	Easier to understand	Strong	general	Strong	general
IDEF series method	Not easy to understand	weak	weak	weak	weak
UML method based on directed graph	Not easy to understand	general	general	weak	general
Petri net modeling	general	Strong	More accurate	Strong	specification

2.2 Petri Net Modeling Process Model Formation

This section proposes a method for transforming a Petri net-based process model into a scientific workflow model to manage the coupled computing task flow of the electromechanical engine in the workflow management system.

The workflow reference model shown in Figure 1 is based on the workflow engine. The workflow execution service is used to make the workflow run. By executing the service and management of the process definition tool, the client application, the calling application, and other workflows. The definition of five types of interfaces, such as monitoring tools, completes the workflow reference model [4].

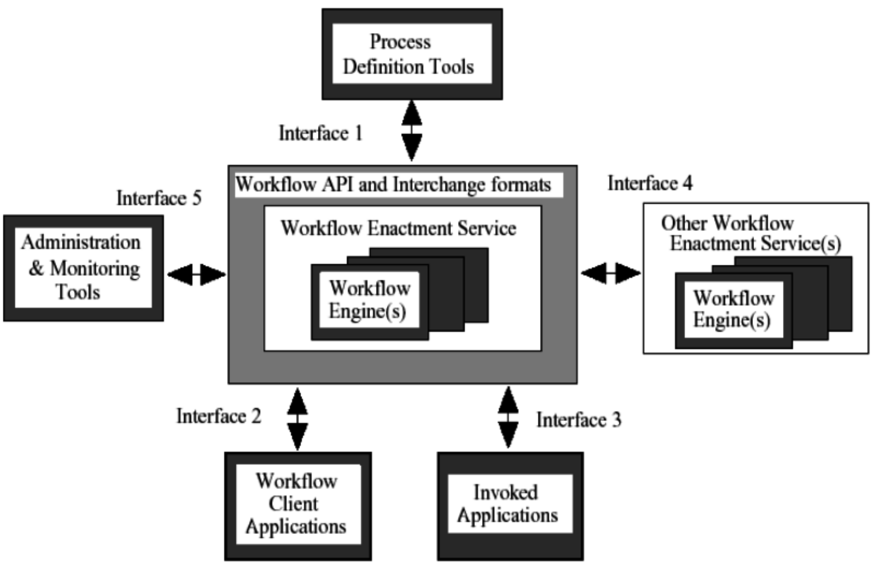

Fig. 1 Workflow reference model

2.3 Petri Net Model is Transformed into Workflow Model

Firstly, the starting library in the Petri net is the premise of all task processes, replacing the starting library in the Petri net model with the starting condition in the workflow model. Secondly, the end library in the Petri net is the identifier of the end of the entire task flow, replacing the end library in the Petri net model with the termination condition in the workflow model. Thirdly, in the Petri net model, other libraries except the start library and the end library can be replaced with directed arrows in the workflow model. Fourthly, the transition in the Petri net is the set of all subtasks of the entire workflow, replacing the transitions in the Petri net model with the tasks in the workflow model.

In the following, according to the conversion rule shown in the above figure, the Petri net model of the above-mentioned electromechanical engine coupling calculation task is converted into a workflow model, and the conversion result is shown in Fig. 2, and the three virtual transitions T in the Petri net model are converted into work. The virtual tasks of the flow model VT1, VT2, VT3, virtual tasks do not need to consume computing resources and execution time when executed.

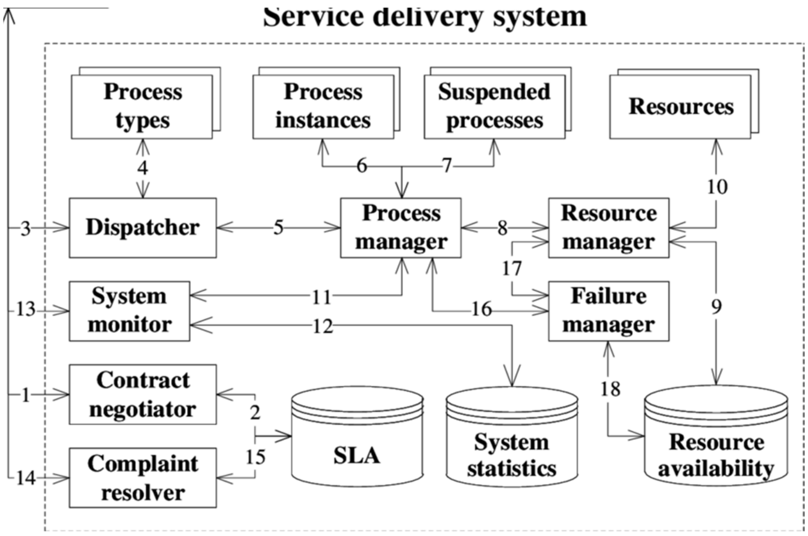

Fig.2 Engine coupled computing task workflow model

3. Simulation Resource Integration Scheme based on Scientific Workflow

3.1 Vistrails Visualization Method of Simulation Results

The scientific workflow management platform VisTrails has built-in visual support API for the Visualization Tool Kit (VTK). VTK is an API that has powerful 3D graphics capabilities and supports cross-platform and parallel processing. It can monitor the entire workflow data by calling the API of the lightweight visualization function provided by the system. The defined data display module is the same as other functional modules. It must first initialize the module, define the basic information of the module and the input and output data type interface [5]. Part of the code for using the data display module is as follows.

```
f=open (Net, 'r +')
Content =f. read ()
p=re. Compile (r'^ Net: (. *)', re, M)
l=re. Find all (p, content)
Ll = []
Foriinl:
m =string. Atof (i)
L1. append (m)
```

The function of the program is to open the result file of the simulation analysis according to the working path, read the content of the file saved in the Content and convert the data content into a digital format, and save it in the list L1. Figure 3 shows the process of integrating the simulation software by the scientific workflow management platform Vista bras.

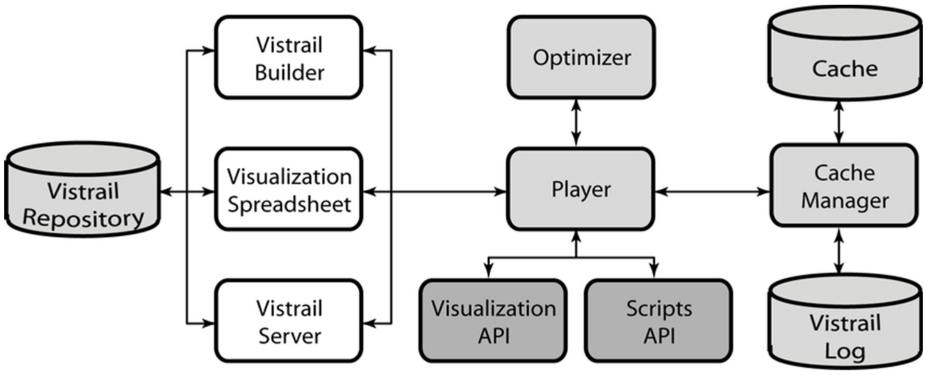

Fig.3 VisTrails integration flow chart of software resources

3.2 Multi-dimensional Simulation Coupled Computing Management System Design based on Scientific Workflow

3.2.1 Overall Design of Multi-dimensional Simulation Coupled Computing Management System

In this paper, based on the multi-dimensional simulation coupled computing management system developed by VisTmils, in order to realize the interdisciplinary collaborative simulation coupling computing function of complex products in a distributed environment, the following five objectives must be realized from the overall requirements of the simulation calculation process:

(1) Standardization of simulation mode. Relevant technical architecture, extended mode, software and hardware communication mode, application process definition, experimental process definition and description, knowledge and data exchange mode, visual and visual analysis related interface, graphical user interface, etc. all need to comply with relevant specifications.

(2) Automation of the simulation calculation process. The main purpose of the system is to reduce computing costs, shorten the development cycle, liberate human intellectual resources and focus on method innovation and scientific problem solving. Therefore, the platform needs to be highly automated, reducing all unnecessary human involvement and manual repetitive work. The entire simulation calculation process should be customizable, editable, supervisory, and controllable.

(3) Synchronization of simulation resources. The system essentially includes a series of coordination problems such as human-machine collaboration, everyone collaboration, software and hardware resource coordination, data and knowledge collaboration, and distributed collaboration. It needs to have a good and complete collaborative logic model.

(4) Openness of the system platform. The system should be able to integrate existing and future predictable types of simulation resources, including commercial software, self-developed software and various database knowledge bases. Therefore, it must have good openness and should have good secondary development capabilities.

(5) System deployment flexibility. The system's technical architecture should have the technological potential to span across platforms in the future, and have the technical capabilities to cope with different deployment models.

In order to make the system meet the above requirements, the functional structure diagram of the multi-dimensional simulation coupled computing management system based on the scientific workflow VisTmils is shown in Figure 4.

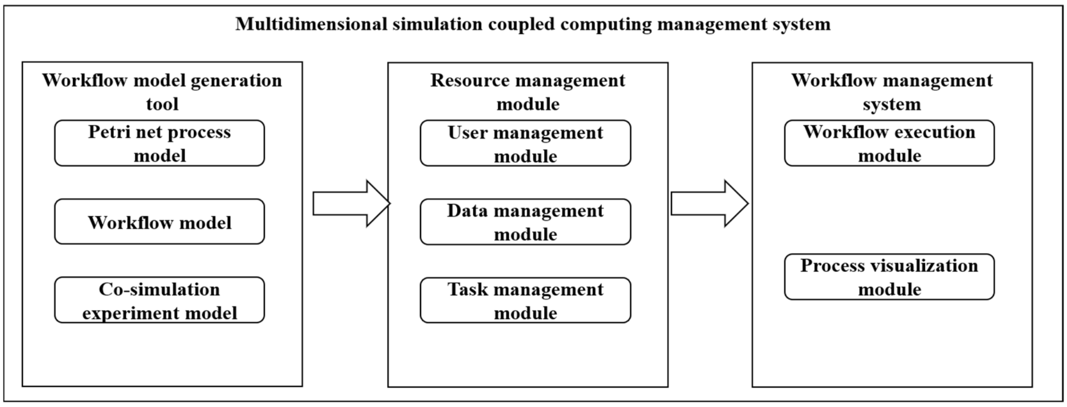

Fig.4 System structure design

3.2.2 System Database Design

The database of the multi-dimensional simulation coupled computing management system developed based on the VisTrails platform is designed and developed on the basis of MySQL. The database entity of the system - contact (E-R: entity-relationship).

The relational mode can be obtained by the multi-dimensional simulation coupled computing management system database E-R model: user (user ID, user name, password, creation time, role). File (file ID, user ID, folder ID, file name, file path, file type, file description, file version, storage method, storage time). Project (project ID, user ID, system version, project name, project type, project description, project version, creation time, main file, process file, IP). Project file (project file ID, project ID, file ID). Project execution (project execution instance ID, project ID, user ID, execution status, execution description, execution time, execution flow ID, node IP). Execution file (execution file ID, project execution instance ID, file name, file path, file type, file description, storage method, storage time). File label (file label ID, label content). The file label correspondence (file label correspondence, relationship record ID, file ID, file label ID). In the relation mode, the underlined field is the primary key in the table, and the field with the wavy line is the foreign key in the table.

The Files management table is mainly used to record the file ID, name, type, path, and storage time. Table 2 shows the file management table structure.

Tab.2 File Management Table Structure

Name	Type of data	Foreign key	Description
File ID	integer	FALSE	File id
User ID	integer	TRUE	User id of the created file
File Name	Varchar (200)	FALSE	File name, excluding path
File Path	Varchar (200)	FALSE	File path, depending on the type of storage
File Type	Enum ('mesh', 'other')	FALSE	The file type, determined by the suffix name, etc., such as cad files, grid files, data files, etc. Specifically, the design file version count is required, and the current provisioning process is currently required.
File Version	integer	FALSE	The order guarantees its uniqueness, not through the function of the database itself. The file version is uniquely determined by Store Time.
Store Type	Enum ('win', 'linux', 'ftp', 'http')	FALSE	Storage mode type, win identifies windows local file system, linux indicates linux file system, ftp indicates ftp path, and http indicates network path
Store Time	TIMES TAMP	FALSE	File storage time, this time is used to uniquely identify the version

3.3 Analysis of Simulation Results

The multi-dimensional simulation coupled computing management system developed by the scientific workflow management platform VisTmils is used to integrate the design resources and simulation models involved in an electromechanical engine coupling calculation task. And the simulation software of different disciplines involved in the co-simulation process, including commercial software ANSYS Fluent and self-developed software. Through the coupled computing management system developed in this paper, the multi-dimensional simulation coupling cross-computing task of electromechanical engine for thermodynamics and fluidics simulation can be fully automated. Through the operation of the examples in this chapter, the effectiveness of the software resource integration technology proposed by the scientific workflow management platform and the Yinyang division platform is verified.

4. Conclusion

This paper first analyzes the characteristics of the co-simulation coupling calculation process based on scientific workflow. After comprehensively comparing various co-simulation process modeling methods, the Petri net-based modeling method with better comprehensive performance is selected. After studying the process modeling technology based on Petri net, the Petri net model is transformed into a workflow model that can be identified by the scientific workflow management platform according to the model transformation rules, which makes up for the shortcomings that the workflow model cannot describe the dynamic working process. This paper progresses on the simulation resource integration method of the scientific workflow management platform VisTrails. At the same time, in order to enhance the flexibility and scalability of the scientific workflow management platform, a scientific workflow management platform and SOA architecture integration method is proposed. The loose coupling feature is integrated into the workflow management system, and the task flow in the workflow is completed according to the service defined in the SOA, and the configuration and management of the simulation resource by using the scientific workflow management in the distributed environment is realized.

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